Eerola, T. (2014). Similarity, Melodic. In Thompson, W. F. (Ed.), Music in the Social and Behavioral Sciences: An Encyclopedia (pp. 1003-1006). London, UK: SAGE.

Similarity (melodic similarity)

Melodic similarity is a very important concept that enables us to recognise themes and appreciate quotations, repetitions, ornamentations and variation of themes. Research into melodic similarity has been carried out by researchers working in music psychology and cognition, music information retrieval and music theory. In this chapter, the main types of melodic similarity are presented together with examples and indicators of how they are implemented and assessed.

The clearest case of melodic similarity is the comparison of two melodic phrases. If the melodies contain similar short patterns of pitches or rhythms, or resemble one another in terms of shape, they are usually evaluated as being similar. The first kind of similarity here is *pattern similarity*, and the latter is *contour similarity*. One can also distinguish *global similarity*, which is a combination of various representations of melodies.

Before going over the types of similarity in detail, let us note a few inherent assumptions in such similarities. Before any meaningful comparisons of two melodies can be made, some indication of what are comparable segments needs to defined (phrases, whole melodies, or short motifs). *Segmentation* itself is a separate topic, but vital for isolating the patterns for melodic similarity. Another issue is *tempo* and *octave invariance* since one usually seeks to identify melodies as similar despite any differences in tempo or register. Many symbolic representations of music adopt this assumption naturally since they do not even carry detailed information about performed tempo – or even register in the case of interval representation. This leads to an important an important aspect of similarity, namely the *reduction* of musical surface. For instance, if melodic intervals are used as the underlying representation, intervals can be represented by either semitones or coarser representations, such as patterns of ups and downs which ignore size altogether. Finally, all computational models of similarity refer to *distance measures*, which is an inverse of the similarity.

Pattern similarity

As listeners, we remember and recognise patterns of pitches and rhythms. Music psychologists have identified such musical motives as essential cues in organising music, and have obtained evidence that they indeed direct attention and are well remembered and identified. Pattern similarity addresses this by identifying salient patterns using several techniques. The simplest ones have been adopted from information-retrieval concerning texts and utilise string-matching principles. In this, segments of music are typically treated as a sequence of pitches, durations or intervals (the latter one in panel A of the Figure 1), either as exact representations of semitones (A1) or as an inexact representation of intervals (A2). Inexact coding can be as simple as merely coding the Up-Down-Repeated quality of the intervals.

A pattern of strings can be compared with other patterns of strings by aligning them accordingly and assessing how many alterations are necessary to transform one string pattern to another. This is known as the *edit distance* measure, which was invented in the sixties by Vladimir Levenshtein and forms the backbone of string-based similarity measures. The edit operations are able to handle additions, deletions and replacements of strings so they can cope with comparisons between sequences of different lengths, which is important since musical segments are usually different in length. Edit distance can be modified by assigning different costs to each type of edit operation. In music, the calculations can also be weighted by the perceptual importance of the note events, such as assigning more weight to metrically important locations or notes with longer durations (see C in Figure 1).

More recent variants of edit distance such as Earth Mover's or Proportional Transportation Distance combine the weights of the strings and treat the strings as probability distributions. For instance, Rainer Typke (2007) and his colleagues have made several large-scale studies supporting these measures as robust estimations of melodic similarity.

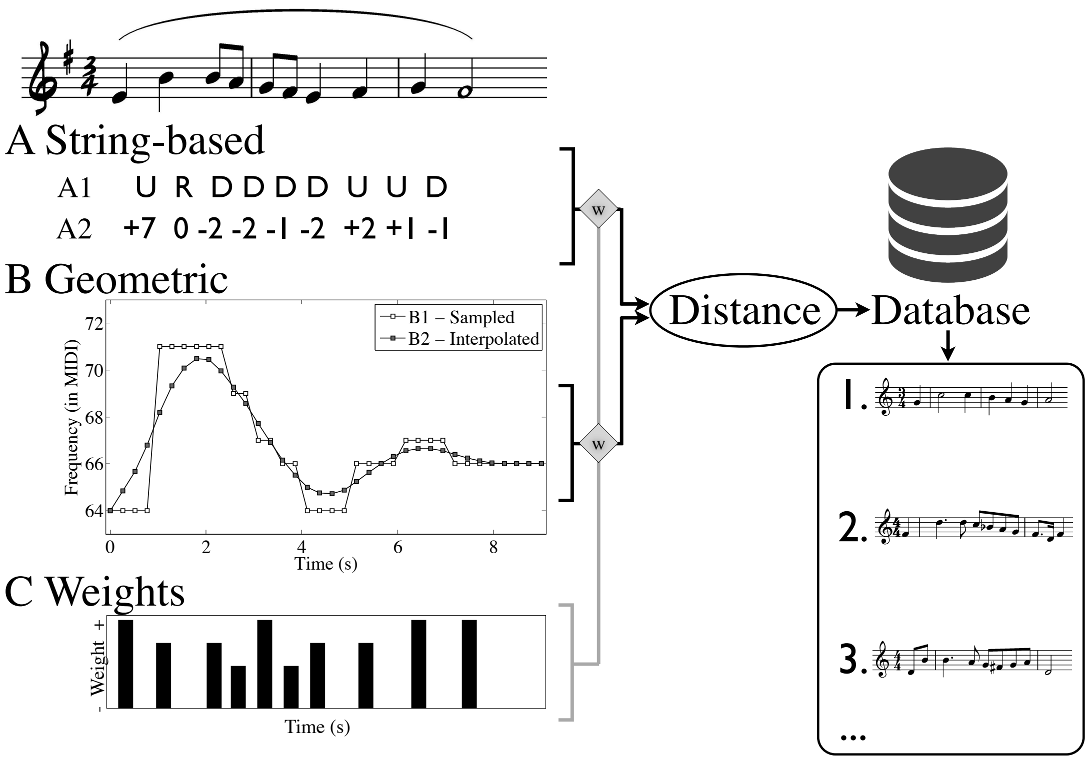
Another way in which pattern similarity has been assessed is via statistical regularities. In this approach, the probabilities of the successive musical events are encoded as n-grams. These may have different sizes; an n-gram of size 2 (called a bigram) consists of pairs of successive pitches or intervals. N-grams of higher orders (e.g. trigrams, 4-grams) are more specific and have been observed to have generally higher relevance for melodic similarity.

Contour similarity

Another way two melodic phrases can be compared is to look at the overall shape of their pitch trajectories. These are called melodic contours and are known to be perceptually of high importance. A stream of studies, started with Jay Dowling's study in 1978, have established how listeners detect differences in transposed melodies more easily if the contour is violated. Also, contour information is something that all listeners can tap into regardless of their musical expertise. During the last decade, neuroscientists have also corroborated that melodic contour is more readily accessible than intervallic information, and changes in contours are detectable even when attention is not devoted to the music listening task.

Melodic contour may be defined in several ways. One is to map the frequency over time simply by just sampling each point in time or carrying out some form of reduction of this shape by interpolating or sampling it less frequently (B1 and B2 in Figure 1). The advantage of contour representation is that it preserves the time-frequency patterns and is able to eliminate some ornamentations and minor variations of these patterns by concentrating on the overall shape of the pattern.

Again, when the similarity of two contours is compared, we speak of geometric distance calculation. There are several common distance metrics available, such as Euclidean or Manhattan distance. Again, the contours may be weighted by musically meaningful information such as tonality, metrical hierarchy, or dynamics to improve the relevance of comparisons. Some researchers have also elaborated contour-based similarity measures by quantifying the recurring patterns within the contour.



Global similarity
Though pattern and contour-based representation of melodic similarity tend to be more frequent in the literature, some researchers have sought to establish *global measures* of similarity based on multiple descriptive features of melodies. Such features may consist of range, prevalent durations, intervals, mode, archetypical structure, melodic direction, and harmonic profile. Aggregated combination of such descriptors has been successful in some studies (Eerola et al., 2001), but since global similarity includes aspects of pattern and contour similarity, in terms of parsimoniousness they are less satisfactory models of similarity than the individual models.

Empirical evidence

While researchers in music cognition have used empirical experiments to refine similarity measures, engineers and computer scientists have attempted to build workable similarity ranking systems whose primary focuses are usability and efficiency rather than the explanatory power of the underlying model. The former have several ways of obtaining relevant indicators of melodic similarity. One approach, called the pair-wise similarity rating task, is to ask listeners how similar are two melodies on a scale. Another method involves asking participants to rank order a set of melodies in comparison to a target melody. Variants of these also exist, such as recognition tasks where the participants are asked to recognise the melody amongst sets of melodies containing foils (false melodies containing various degrees of differences to the original). The results of many empirical experiments have found support for each form of similarity (pattern, contour, and global), and recent research tends to favour local pattern similarity as the optimal component of similarity (e.g. Kranenburg et al., 2013).

Applications of melodic similarity

Several symbolic databases contain search functionality based on melodic similarity (e.g. themefinder). Also, query-by-humming, where you sing or whistle a part of the melody to obtain the desired tune from the database, capitalises melodic similarity (e.g. Midomi, SoundHound). Before the advent of these technological solutions, scholars have been organising music collections according to tune families (e.g. national collections of Hungarian and Finnish music) and thematic similarity (e.g. Barlow's dictionary of musical themes).

Future directions in melodic similarity will involve better estimations of similarity which is less sensitive to variation and ornamentation (more human-like, dynamic pattern matching), increased sensitivity idiosyncratic patterns of different musical cultures and support for non-notated and improvised music, which in turn, requires seamless cooperation with pitch estimation.

Tuomas Eerola
Durham University, UK

See Also: Database studies; Computer aided musical analysis; Pattern; Melody processing

Further readings

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